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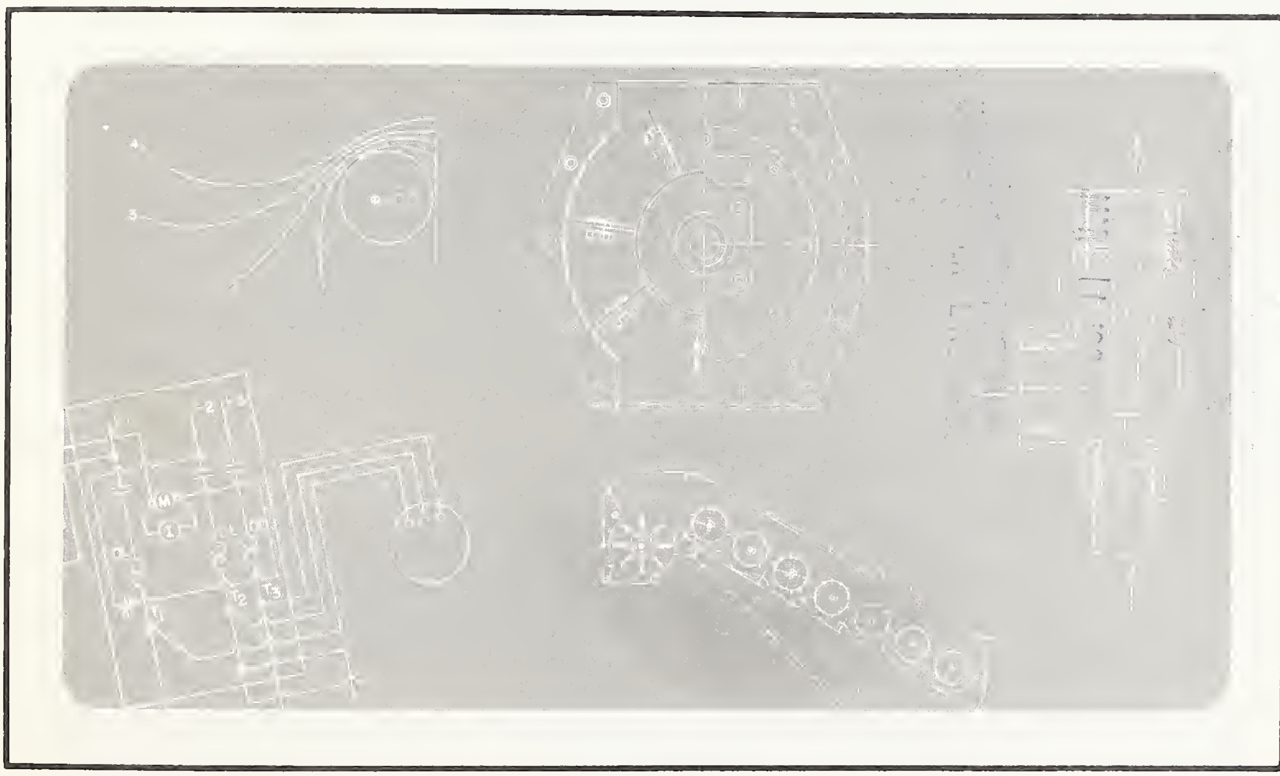
Shipping Fresh Fruits and Vegetables in Mixed Loads to the Caribbean



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Shipping Fresh Fruits and Vegetables in Mixed Loads to the Caribbean

By L. A. Risse, W. R. Miller, and T. Moffitt[1]

ABSTRACT

Eleven ocean shipments were made in efforts to improve the arrival condition of fruits and vegetables through improved handling procedures and refrigeration-equipment design. This report describes the results of these shipments and provides shippers and carriers in the United States and receivers in the Caribbean area with specific guidelines for loading, shipping, and distributing these products. In eight shipments, tightly stacked and air-stacked loads were compared for product and air temperature control in conventional van containers. The remaining shipments involved a comparison of these temperatures for tightly stacked loads in a USDA-developed van container, which delivers refrigerated air under the load, and air-stacked loads in a conventional van container, which delivers refrigerated air above the load. The air-stacked loads in the first tests cooled more rapidly and uniformly than the tightly stacked loads. But the tightly stacked loads in the USDA van cooled faster and more uniformly than the air-stacked loads in the conventional van. In most shipments, properly stacked boxes and products arrived in satisfactory condition, but some temperature-sensitive products, such as tomatoes, peppers, eggplant, and grapefruit, showed chilling injury and the effects of decay. Index terms: containerization, loading patterns, ocean shipment, perishable plant products, refrigerated van containers, temperature control.

INTRODUCTION

Exports of fresh fruits and vegetables from the United States to the Caribbean have expanded from $7.5 million in 1975 to $19.3 million in 1980 (Foreign Agricultural Service, USDA, unpublished data). This increasing demand for these products is attributable to the growth in tourism, the rising standard of living of most households in the Caribbean, and the reduction of some trade barriers. The Caribbean market area, as defined by the Foreign Agricultural Service for statistical purposes, includes the following islands or countries: Bermuda, Bahamas, Jamaica, Turk and Caicos Islands, Cayman Islands, Haiti, Dominican Republic, Leeward and Windward Islands, Barbados, Trinidad and Tobago, Netherlands Antilles, and French West Indies. Even though Puerto Rico is located in the Caribbean, it is not considered part of the export market because it is a part of the United States.

The geographic area of the Caribbean market is tropical, and mean ambient temperatures are high. Many of the islands are small with small

[1]Agricultural marketing specialist, agricultural marketing specialist, and industrial engineering technician, U.S. Horticultural Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, 2120 Camden Road, Orlando, Fla. 32803.

Table 1.—Log of test shipments from Florida to various destinations in the Caribbean, 1976–81

Test No.	Date of shipment	No. of products[1]	Type of van container	Destination	Transit time (hours)
1	June 1976	7	Conventional	Puerto Rico	122
2	June 1976	19	Conventional	Curacao	192
3	June 1976	5	Conventional	Puerto Rico	116
4	June 1977	29	Conventional	Puerto Rico	146
5	June 1977	6	Conventional	Puerto Rico	116
6	July 1977	16	Conventional	Curacao	178
7	September 1978	35	Conventional	Curacao	170
8	September 1978	33	Conventional	Curacao	168
9	February 1981	23	USDA	Curacao	144
10	March 1981	23	USDA	Curacao	148
11	March 1981	23	Conventional	Aruba	120

[1]Number of different fresh fruits and vegetables included in each shipment.

populations, but when considering the area as a whole, the Caribbean market is quite large. The high ambient temperatures subject the mechanically refrigerated equipment used on the van containers to high stress levels, thus lowering the efficiency of the equipment. The volume of many fresh fruits and vegetables exported to a particular market in the Caribbean is relatively small; therefore, many different products are combined into mixed loads. The results of many observations and studies made in this market area show that product losses are high, particularly in mixed loads.

In the past, shipments of fresh products to the Caribbean area were transported on small breakbulk ships and tour boats, and transit times were usually in excess of 10 days. The advent of containerization (roll-on/roll-off and lift-on/lift-off) and subsequently scheduled routes have improved the potential for shipping perishable items to the Caribbean market. Regularly scheduled sailings of container ships are now offered to most islands of the Caribbean on a weekly or biweekly basis, with transit times of 3 to 7 days. Major United States ports serving the Caribbean are New York-New Jersey, Jacksonville, Miami, and New Orleans, with transfer shipments from many other ports, particularly San Juan, Puerto Rico.

The advent of containerization has brought many improvements in the designs of the refrigeration unit and the van container, which must function as an integral unit to provide the proper environment for maintaining the condition of highly perishable products during transit.

Poor air distribution and inadequate stacking patterns often lead to large variations in temperature within a van container, which results in damage to products from freezing or overheating. Air-stacking patterns that allow refrigerated air to move through rather than around the load have been developed for most fresh fruits and vegetables in straight loads (Ashby 1970). Improvements have also been needed in the air-delivery system to the cargo area (Breakiron 1974, 1977; Goddard 1974; Hinds 1978). The U.S. Department of Agriculture has developed and tested the concept of an under-the-floor forced-air distribution system (down the side walls and across the width of the van container) in cooperation with private industry. This system maintains uniform product temperatures under commercial conditions and improves air distribution, thus eliminating the need for air-stacking patterns (Hinsch et al. 1978, McDonald et al. 1979, Stewart 1976, Risse et al. 1980). Another system (Hinds 1978, Hinsch et al. 1981) has been developed to deliver the refrigerated air at the bottom front of the van container or trailer. From the front, the air flows under the load through 3-inch-high aluminum extrusions (T-rails) to the rear of the van container, where a piece of canvas is positioned over the end of the T-rails and under the last stack of boxes. The canvas prevents the refrigerated air from circulating around the load and forces the air up through the load, either around each box or through the box of product.

Most refrigerated shipments to the Caribbean are in mixed loads consisting of several to as many as 35 different fruits and vegetables in each van container. Some products shipped to Puerto Rico, such as tomatoes, lettuce, apples, and pota-

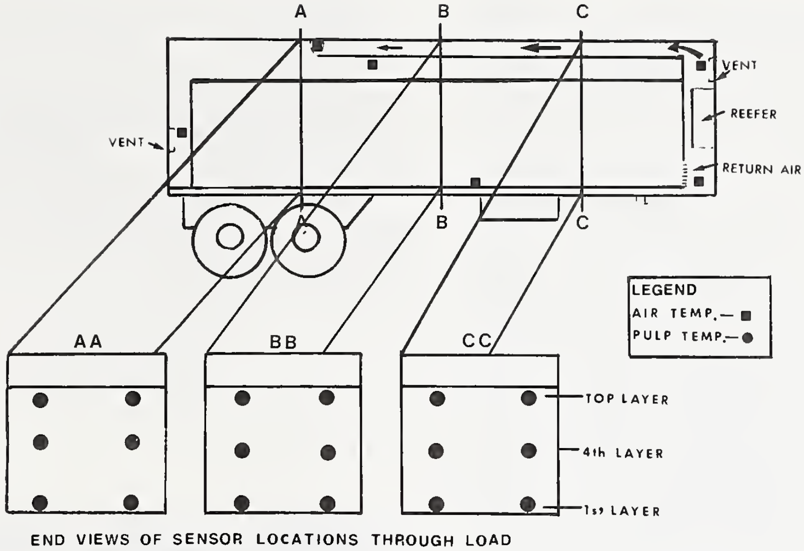

FIGURE 1.—Locations of thermistor temperature sensors used to monitor product and air temperatures in conventional van. In USDA van, discharge-air temperature was obtained at floor of van and return-air temperature at top.

toes, may be loaded in straight loads, i.e., whole shipment of one product. Most shipments, however, are mixed loads. The problems created by mixed loads may be quite severe, because it is difficult to load containers with products packed in different sizes and types of bags, boxes, and crates and still maintain adequate, uniform air circulation throughout the load. Also, it is difficult to keep containers of various sizes and types stacked or braced so that the load will not shift in transit. Another problem encountered is the loading of many containers of various sizes, types, and weights so that physical damage will not occur to package or product during transit.

A major problem with mixed loads is that of shipping incompatible commodities together. The following three important factors should be considered when determining the environmental compatibility of products: (1) the required transit temperatures, (2) whether the products emit volatiles such as ethylene gas that may be harmful to other products, and (3) whether the products give off or absorb objectionable odors (Ashby 1970). The compatibility of fruits and vegetables during transport in mixed loads is summarized by Lipton and Harvey (1977).

The objective of this study was to improve the arrival condition of fresh fruits and vegetables shipped in mixed loads from the United States to the Caribbean through improved handling procedures and refrigeration-equipment design. This report describes the results of 11 test shipments of mixed loads from Florida to the Caribbean area, including Puerto Rico, and provides shippers and carriers in the United States and receivers in the Caribbean with specific guidelines for loading, shipping, and distributing fresh fruits and vegetables.

EQUIPMENT AND PROCEDURES

Eleven test shipments of mixed loads were monitored from the ports of Jacksonville and Miami, Fla., to San Juan, Puerto Rico, and Curacao and Aruba, Netherlands Antilles. Table 1 lists the following data for each shipment: date of shipment, number of products, type of van container, destination, and hours in transit.

In each shipment, product and air temperatures were monitored at selected locations throughout each van container[2] (fig. 1). Thermistor sensors attached to a battery-operated recorder were used to record temperatures, either every 30 minutes or hourly from the time of loading until unloading. A total of 18 product and 6 air temperatures were recorded in each conven-

[2]Van containers are hereafter referred to as vans.

tional and USDA-developed van. In the USDA van, the discharge-air temperature was obtained at the floor of the van and return-air temperature at the top, just the opposite of the system in the conventional van (fig. 1).

The principal difference between the conventional and USDA vans is in the air-circulation system. In the conventional van, when a shipment is loaded in an air-stack loading pattern, refrigerated air (discharge air) moves through a canvas duct from the front, above the load to a point three-fourths the length of the van, down the rear and sides of the load, through the load to the floor channels (which run lengthwise), and back to the air return at the bottom of the front bulkhead. If the shipment is not air-stacked, the air circulates only around the perimeter of the load. In the USDA van, refrigerated air (discharge air) enters at the bottom of the front bulkhead and moves from front to rear through the floor channels. A piece of canvas placed over the ends of the floor channels at the rear of the van and under the last stack of boxes blocks the air and forces it up through the load to the overhead space above and back to the air return inlet at the top of the front bulkhead. Another difference is that in the conventional van the discharge-air temperature is controlled by a thermostat located in the return air, whereas in the USDA van the thermostat for this measurement is located in the discharge air.

On arrival of each shipment, observations were made of the condition of the packaging, the condition of the product, and the stability of the boxes in each load. In the air-stacked shipments, particular emphasis was placed on examination of the boxes to determine if damage was the result of the air-stacking.

RESULTS

Temperatures

The averages and ranges of product temperatures at loading, at selected times during transit, and on arrival for the 11 test shipments are shown in table 2. Generally, the averages and ranges of product temperatures during transit were lower in the precooled shipments than in the nonprecooled shipments. In test shipment 3, a nonprecooled shipment with the thermostat setting at 55° F, there was a range in product temperature of 19° F on arrival. In the other nonprecooled shipments (1 and 5), there were ranges in product temperatures of 15° and 13° F, respectively, after 24 hours in transit.

Table 2.—Averages and ranges of product temperatures at selected times during test shipments from Florida to various destinations in the Caribbean, 1976–81

Test No.	Loading pattern	Thermostat setting (°F)	Load precooled	Temperatures at loading, average and range (°F)	Average and range of temperatures (°F) after— 24 hours	48 hours	72 hours	Temperatures on arrival, average and range (°F)
1	Tight-stack	39	No	51(40–60)	43(35–50)	40(35–48)	39(36–44)	39(37–43)
[2]2	Mostly air-stack	40	Yes	....	....	....	....	41(39–44)
3	Tight-stack	55	No	77(53–84)	65(48–76)	61(47–71)	59(47–69)	57(47–66)
4	Mostly air-stack	38	No/Yes	54(36–69)	42(37–45)	37(35–40)	38(36–40)	37(35–40)
5	Air-stack	39	No	54(42–76)	42(34–47)	39(34–47)	39(35–45)	38(37–43)
6	Tight-stack	38	Yes	42(35–55)	41(36–45)	41(38–45)	41(38–45)	41(38–45)
7	Tight-stack	38	Yes	46(40–50)	43(39–48)	42(39–48)	42(39–47)	41(39–46)
[2]8	Air-stack	38	Yes	45(40–50)	....	....	....	40(38–42)
[3]9	Tight-stack	38	Yes	45(39–51)	41(37–45)	[4]43(41–47)	42(40–44)	40(38–42)
[3]10	Tight-stack	38	Yes	46(39–57)	44(40–52)	42(38–47)	42(38–45)	40(37–43)
11	Mostly air-stack	38	Yes	46(40–57)	42(38–44)	42(36–45)	42(35–45)	41(35–46)

[1]Load precooled means that the shipment was temporarily stored before loading at near the desired storage or transit temperature for the products involved.

[2]Malfunction in recording instrument.

[3]Shipment was in USDA van; all other shipments were in conventional vans.

[4]Ice-up of refrigeration unit during transit between 24 and 48 hours after loading caused average and range in product temperature to increase.

Air-stacked shipments (fig. 2 and table 2) cooled faster and with a narrower range in temperature extremes than tightly stacked shipments (fig. 3) when loaded in conventional vans, because the air could circulate through the loads instead of around them. In the tightly stacked shipments, the coldest product temperatures were in the top layers and in the front stacks of the van, while the warmest temperatures were in the middle of the load. In properly loaded air-stacked shipments, temperatures were more uniform throughout the load. Figure 4 shows the high and low product temperatures of typical tightly stacked and air-stacked shipments for comparison. The ranges in product temperatures for the tightly stacked shipment were greater than the ranges for the air-stacked shipment. The highest temperatures in the tightly stacked shipment were in the center of the load, which the refrigerated air could not reach.

The ranges in product temperatures during transit and upon arrival (4° and 6° F) in the USDA van (table 2) were more uniform than the ranges in product temperatures in the conventional vans. Using figure 5, a comparison can be made of the high and low product temperatures of shipment 11 in a conventional van and shipment 10 in the USDA van. In the USDA van, the coldest product temperatures were in the bottom layer of boxes, and the warmest temperatures were in the top layer of boxes. In the conventional vans, the coldest product temperatures were in the top layer of boxes, and the warmest temperatures were in the middle and bottom layers of boxes, in both air-stacked and tightly stacked loads. In the USDA van, the coldest product temperatures were at or slightly above the thermostat setting, whereas in the conventional vans, the coldest product temperatures were generally lower than the thermostat setting. The reason for this difference is that the thermostat in the USDA van is located in the discharge air, and in conventional vans it is located in the return air.

(Continued on page 8.)

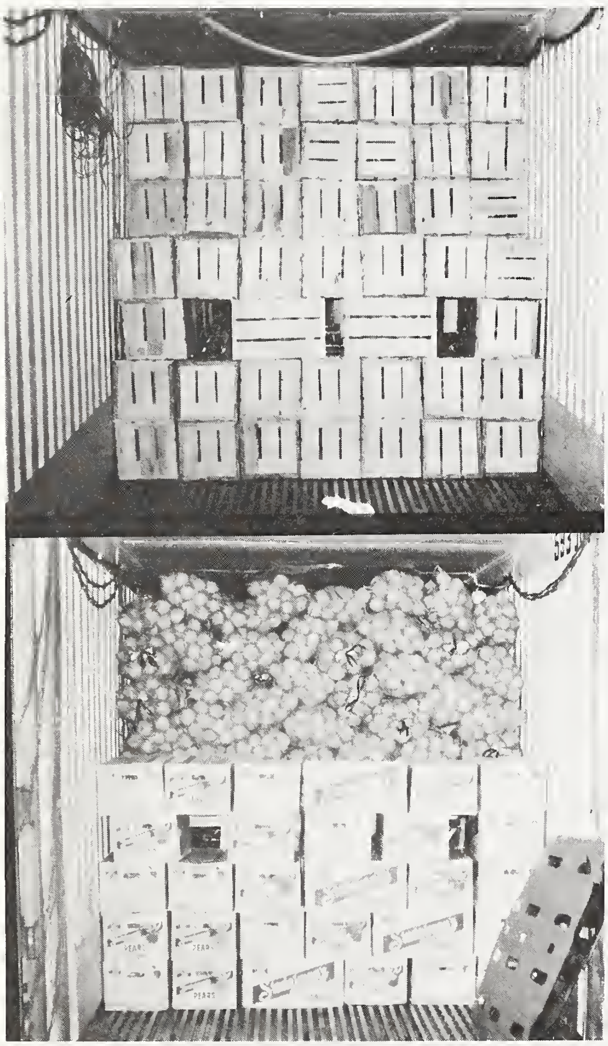

Figure 2.—Air-stacked shipments in conventional vans. Top, air-stack pattern used with crates or boxes of the same size and shape; bottom, air-stack pattern used with boxes and bagged products on top.

Figure 3.—Tightly stacked shipment in USDA van. Most shippers use this loading pattern. Note canvas positioned over T-rails and under last stack of boxes in van to block refrigerated air.

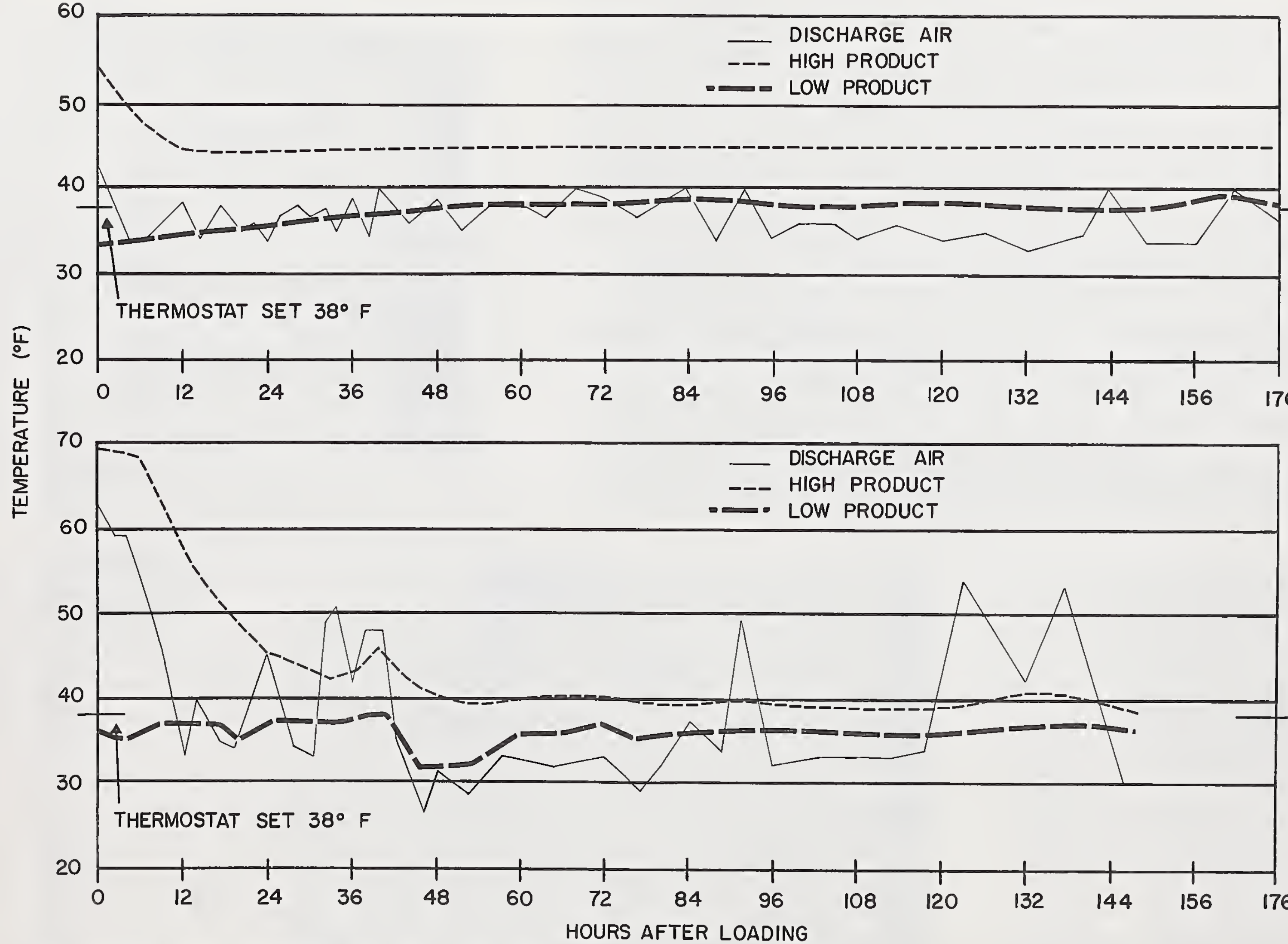

FIGURE 4.—Discharge-air temperatures and high and low product temperatures in conventional vans. Top, tightly stacked shipment 6 from Florida to Curacao, 1977; bottom, air-stacked shipment 4 from Florida to Puerto Rico, 1977.

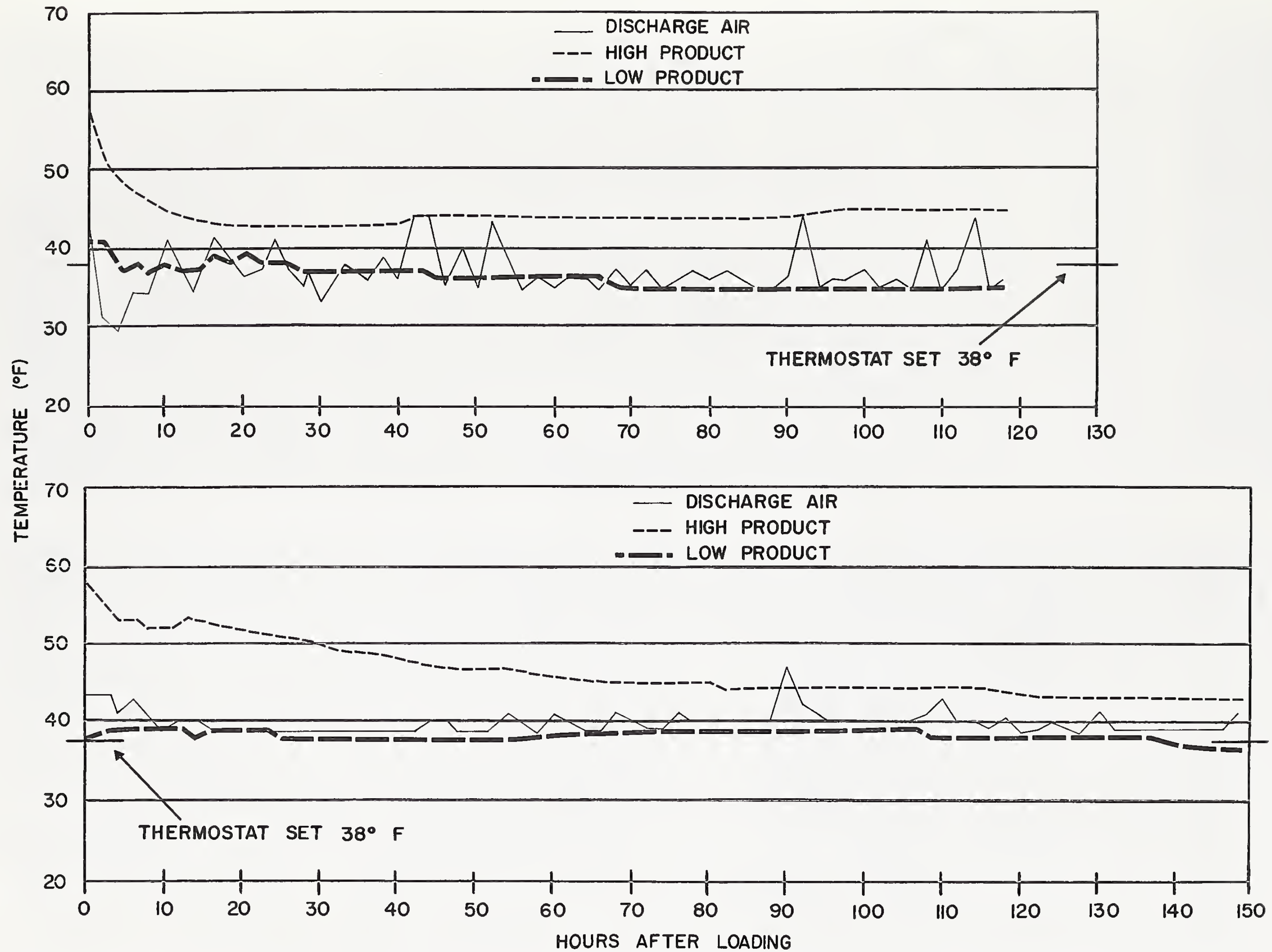

FIGURE 5.—Discharge-air temperatures and high and low product temperatures in conventional and USDA vans. Top, conventional van shipment 11 from Florida to Aruba, 1981; bottom, USDA van shipment 10 from Florida to Curacao, 1981.

Boxes and Products

The properly stacked boxes and products arrived in satisfactory condition, including the boxes in the air-stacked shipments. In a few shipments in which bagged products (onions, carrots, or potatoes) were on top of fiberboard boxes, the boxes showed considerable crushing from overhead weight on arrival. In one shipment, crates of celery stacked on fiberboard boxes of lettuce caused damage to both the boxes and the lettuce. In another shipment, crates of cabbage stacked on boxes of tomatoes caused damage to the tomato boxes and the tomatoes. In another shipment, the van was not loaded to the rear doors, and some boxes shifted during transit and fell into the void space between the load and the rear doors, thus causing box damage and crushing of lettuce in the boxes. During a shipment in a conventional van, water dripped from the refrigeration unit (part of the unit is situated inside these vans) onto paper sacks of potatoes stacked under the unit, which resulted in some bag breakage at unloading.

In most shipments, the fresh fruits and vegetables arrived in satisfactory condition, except for some temperature-sensitive products such as tomatoes, peppers, eggplant, and grapefruit. Mature green tomatoes, in particular, had chilling injury upon arrival. In many cases, the chilling injury was only slightly visible (small, black spots), but a few days after arrival the damage was more noticeable and decay, particularly alternaria rot, became a problem. In a few shipments with vine-ripened tomatoes, chilling injury was not so severe. Peppers and eggplant also had chilling injury (small sunken spots) in a few shipments, but not as severely as did the tomatoes. After a few days, the quality of the peppers and eggplant deteriorated rapidly. Grapefruit showed signs of chilling injury (slight pitting and small, black spots), but in most cases the internal quality of the fruit was not affected. However, the pitting did affect the external quality or appearance of the fruit. In several shipments, iceberg lettuce had considerable decay upon arrival because of higher than recommended transit temperatures. Some of this lettuce was 40° to 60° F at loading in Jacksonville and cooled to only about 45° F during transit to the Caribbean. Frequently, lettuce arriving at ports for export in over-the-road trailers has had temperatures in the range of 45° to 60° F (Hinsch et al. 1981). In this study, one or two other commodities had excessive damage upon arrival. However, in most of these instances the damage or decay was not related to transit environment because some damage and decay had been noted at loading.

DISCUSSION

Export of fresh fruits and vegetables to the Caribbean in mixed shipments can be successful, and these perishable products can arrive in satisfactory condition if a few basic guidelines are followed. The export market to the Caribbean has been increasing, and all indications show that the demand for fresh fruits and vegetables will continue to increase. Except for various trade barriers, the limiting factor prohibiting increased shipments is unacceptable quality or condition of the fresh fruits and vegetables upon arrival in this market.

The most important factor in the transport of fresh fruits and vegetables is temperature control. Each fresh fruit and vegetable has an optimum transit temperature (Lutz and Hardenburg 1968, Ashby 1970). In mixed shipments, however, some deviation from the optimum temperature is usually necessary, and the products selected must be environmentally compatible. If the products are of excellent quality and are fresh when loaded and if transit times are kept to a minimum, the products will arrive in satisfactory condition with sufficient marketing shelf life. Certain fresh fruits and vegetables (tomatoes, peppers, grapefruit, etc.) should never be shipped in mixed loads at temperatures below 45° F (Lipton and Harvey 1977).

After the optimum thermostat setting has been established for a given mixed load, the most important factor is to maintain a uniform temperature for the products near the thermostat setting. In conventional vans, the loading of fresh products into an air-stack pattern is necessary for uniform product temperature control. One or two layers of boxes in the load must be stacked in a manner that will provide continuous parallel air channels from the rear to the front bulkhead of the van. Another way to accomplish uniform temperature control around the thermostat setting is by using vans having a bottom-air-delivery sys-

tem similar to that of the USDA van discussed in this report. This type of air-delivery system eliminates the need for air-stacking the load.

RECOMMENDATIONS

The following guidelines should be followed by shippers, carriers, and receivers for successful loading, shipping, and receiving of mixed loads for the Caribbean:

Shippers

1. Buy only the freshest fruits and vegetables possible.
2. Store and precool all fresh fruits and vegetables to their optimum storage temperature before loading, which will require at least two or three storage rooms at various temperatures (i.e., 35°, 45°, and 55° F). But do not store products to be exported for extended periods of time.
3. Before loading a particular shipment, check quality and condition of all products. If a particular commodity is not of sufficient quality to withstand further transit, storage, and distribution upon arrival, do not ship it; find a replacement.
4. Plan loading of each shipment to reduce loading time to a minimum. Move products from refrigerated storage, and load van as quickly as possible to minimize the time products are exposed to ambient conditions.
5. Load and ship only fresh fruits and vegetables that are environmentally compatible, i.e., having similar requirements for temperature and atmosphere. Whenever possible, combine compatible products at one temperature for more than one receiver on the same island or in the same country.
6. In a conventional van, load commodities in an air-stack loading pattern, with continuous parallel channels from rear to front of van in one or two middle layers in load. Do not block air-discharge duct at top of van.
7. Place all bagged products (onions, potatoes, carrots, peanuts, etc.) together, with heaviest items on bottom. Load strongest boxes and crates and heaviest products in bottom layers and weakest boxes and crates and lightest products in top layers. Load boxes and crates of same size and shape together to facilitate air-stack loading.
8. To avoid blocking air circulation around load in conventional vans, do not load products past end of the T-rails.
9. Brace load in rear to prevent shifting of boxes in transit, which may cause damage to boxes and product and possibly block air circulation.

Carriers

1. Supply vans that are fully prepared for shipment, with refrigeration unit calibrated and in proper running operation. Precool vans before loading.
2. When shipment departure is delayed, notify shippers so that they may rearrange loads and provide fresher products. Also notify receivers of any expected delays in receipt of their shipment.
3. Keep transit times for fresh fruits and vegetables to a minimum.
4. Consideration should be given to buying and supplying vans with under-the-floor air-delivery systems.

Receivers

1. When ordering shipments of mixed loads, order only products that are environmentally compatible to be loaded together. Coordinate shipments with other receivers in your country to combine a shipment of homogenous products in one van at one temperature. This precaution is particularly important for tomato shipments.
2. Unload all shipments immediately upon arrival and immediately place products in refrigerated storage at their optimum storage temperature, which may require as many as three storage rooms at various temperatures (35°, 45°, and 55° F).
3. Sell and distribute products as soon as possible because they will have been in storage and transit for 10 to 14 days in addition to being handled several times before reaching your destination and therefore may be near the end of their expected shelf life. This situation is particularly true for most fresh vegetables.
4. When possible, buy straight loads of certain products (onions, potatoes, citrus, apples, etc.) that have an extended shelf life, and store them at your destination.

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